Bryozoans of the Adriatic Sea

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Abstract: Bryozoans of the eastern Adriatic Sea are presented through the distribution and characteristics of the dominant species in the main benthic ecosystems: rocky bottoms, seagrass *Posidonia oceanica* (L.) DELILE meadows, marine caves and soft bottoms. Bryozoan assemblages were surveyed and sampled from 22 sites along the eastern Adriatic Sea coast. Among surveyed biocoenoses, the coralligenous biocoenosis harboured the largest diversity in bryozoans, followed by semi-cave biocoenosis, biocoenosis of seagrass *Posidonia oceanica* meadow and biocoenosis of photophilic algae. Some particular bryozoan assemblages such as large bryozoans that live under the influence of submarine freshwater springs („vruljas“), on the magmatic rocks, dense meadow of *Cellaria fistulosa* and *C. salicornioides* and meadow of *Margaretta cereoides* were also discussed. The bryozoan assemblages of the Adriatic Sea correspond in general to those of the Mediterranean Sea. Since about 400 species have been recorded in the Mediterranean and only 222 species in the eastern Adriatic, future researches are expected to confirm much larger bryozoan diversity in the eastern Adriatic Sea.

Key words: Bryozoa, benthic communities, comparison Mediterranean Sea.

1 Introduction

The first ever described and illustrated marine bryozoan species was a Mediterranean *Reteporella* species, presumably *R. septentrionalis* (HARMER 1933) in 1555 by French professor of medicine RONDELET from the French and Catalan coast (D'HONDT 2002). The first report of bryozoan species from the Adriatic Sea was made two centuries later, in 1750, by DONATI, in Venice, who illustrated the species *Miriozoo* later named *Myriapora truncata* (PALLAS 1766) and included an unnamed *Reteporella* species. After that the most important work on bryozoans was done by HELLER (1867) and HINCKS (1886). FRIEDL (1918) reviewed all previous results and mentioned a total of 137 bryozoan species and 36 subspecies in the Adriatic Sea. The detailed history of the bryozoan research in the Adriatic Sea was reviewed by NOVOSEL & POŽAR-DOMAC (2001). In 2002 HAYWARD & MCKINNEY reported 21 bryozoans new for the eastern Adriatic coast, among which five species were new to science. The most recent paper added 17 species that were reported for the first time from the Adriatic Sea (NOVOSEL et al. 2004). Thus the total number of bryozoan species recorded from the Adriatic Sea until today is 222.

The aim of this paper is to review the most dominant bryozoan species and their assemblages, through the main benthic ecosystems of the Adriatic Sea.

2 Study site and methods

Bryozoan assemblages have been considered through four main benthic ecosystems of the Adriatic Sea: rocky bottoms, seagrass *Posidonia oceanica* (L.) DELILE meadows, marine caves and soft bottoms. Some interesting assemblages such as large bryozoans that live under the influence of submarine freshwater springs ("vruljas"), on the magmatic rocks, dense meadow of *Cellaria fistulosa* (LINNAEUS 1758) and *C. salicornioides* LAMOUROUX 1816 and meadow of *Margaretta cereoides* (ELLIS & SOLANDER 1786) are also discussed.

Bryozoans were surveyed and collected from the following sites (Fig. 1): North Adriatic (Orlandin Rock, Lim Channel, Rovinj, Prvić Island, Sv. Juraj, Žrnovnica Cove, Ždralova Cove, Grmac Cove and Ćutin Island), Central Adriatic (islands of: Silba, Dugi otok, Kornati, Jabuka, Drvenik,

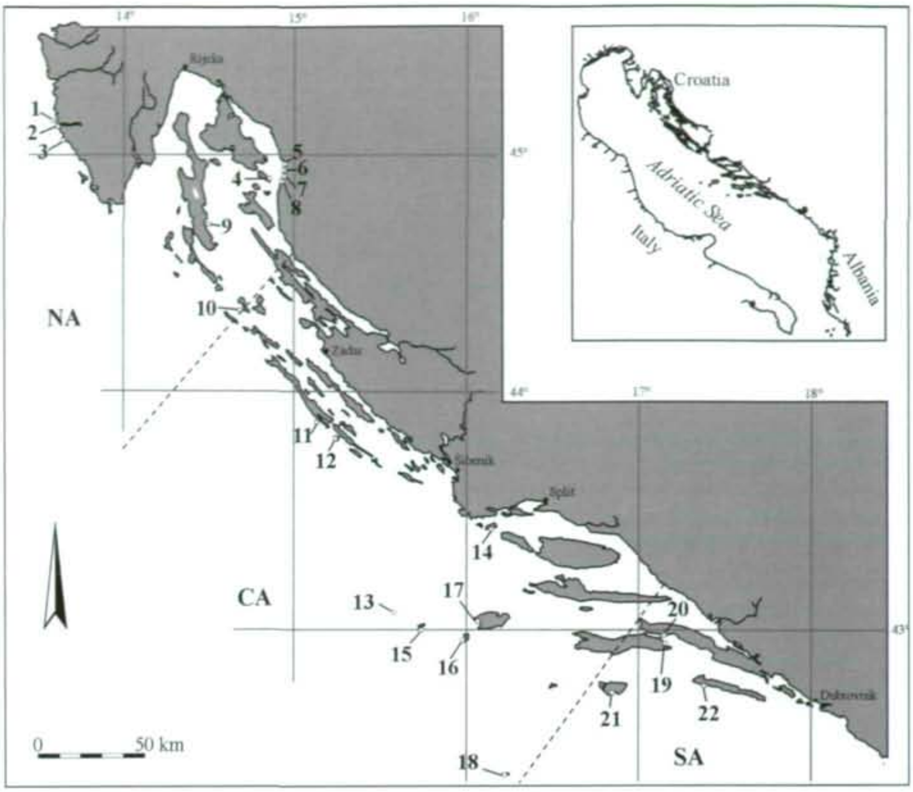


Fig. 1: The eastern Adriatic Sea with the surveyed locations. 1 – Orlandin Rock, 2 – Lim Channel, 3 – Rovinj, 4 – Prvić Island, 5 - Sv. Juraj, 6 – Žrnovnica Cove, 7 – Ždralova Cove, 8 – Grmac Cove, 9 – Cutin Island, 10 – Silba Island, 11 - Dugi otok Island, 12 – Kornati islands, 13 – Jabuka Islet, 14 – Drvenik Island, 15 – Brusnik Islet, 16 – Biševo Island, 17 – Vis Island, 18 – Palagruža Island, 19 – Korčula Island, 20 – Pelješac Peninsula, 21 – Lastovo Island and 22 – Mljet Island. Broken lines indicate division of the Adriatic into North (NA), Central (CA) and South (SA).

Brusnik, Biševo, Vis and Palagruža) and South Adriatic (Korčula Island, Pelješac Peninsula and islands of Lastovo and Mljet). Survey took place between 1995 and 2004, by SCUBA diving, dredging and Peterson grab. Bryozoans were collected from *Posidonia* leaves, algae, shells and other biogenic substrata, stones, sediment, or by scraping colonies from escarpment walls. Bryozoan samples were either dried or preserved in 70 % ethyl alcohol. The division of the Adriatic Sea into North, Central and South was made after GAMULIN-BRIDA (1967). The biocoenoses terms defined by PÉRÈS & PICARD (1964) were applied.

3 Results

3.1 Rocky bottoms

The coastal zone of the eastern Adriatic Sea mainly comprises rocky bottoms including escarpments and rocky bottoms with an angle of inclination about 45° or less. The highest bryozoan diversity was recorded along escarpments and on sloping rocky bottoms with constant and strong currents. The most dominant large erect species recorded along the escarpments of the eastern Adriatic Sea were *Adeonella pallasii* (HELLER 1867), *Myriapora truncata* (PALLAS 1766), *Smittina cervicornis* (PALLAS 1766) and *Schizotheca serratimargo* HINCKS 1886, which characterized the coralligenous biocoenosis.

Adeonella pallasii (Fig. 2) is endemic to the Mediterranean and essentially distributed in the Adriatic and the eastern basin of the Mediterranean. It differs from another Mediterranean species, *A. calveti* CANU &

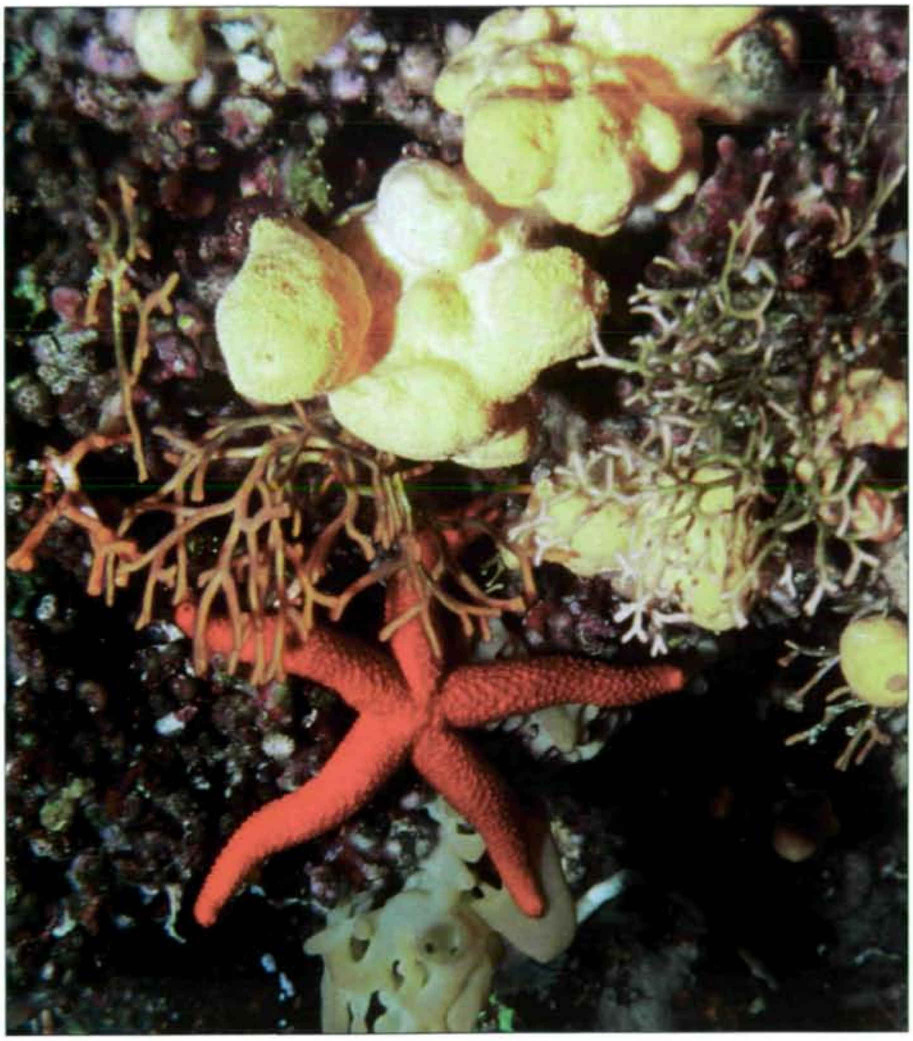


Fig. 2: *Adeonella pallassii*. Foto: J.-G. Harmelin.

BASSLER 1930, which occurs in the western basin, by the orientation of the avicularia. Colonies are large, erect and rigid, with bright orange-coloured dichotomous branches. In this survey, *A. pallasii* was recorded from three localities in the North (4, 8, 9), six in the Central (10, 12, 13, 16, 17, 18) and one in the South Adriatic (21). Colonies were found from 10-50 m depth, mainly along the exposed parts of escarpments. It was particularly abundant in exposed microhabitats along the escarpments of the islands of Prvić and Lastovo. *Adeonella pallasii* mainly grew on hard substratum, although MCKINNEY & JAKLIN (2001) recorded this species closely associated with two *Cellaria* species on muddy sediment at 35 m depth in the North Adriatic.

Beania magellanica (Fig. 3) is widely distributed in the Mediterranean, Atlantic and Pacific. Colonies form brownish and membraniporiform sheets. In this survey, *B. magellanica* was recorded from five localities in the North (4, 5, 6, 8, 9) and two in the Central Adriatic (13, 18). The species was found both in sheltered and exposed habitats, from 10-45 m depth, mainly as epibiont on different biogenic substrata. Thus, it was recorded from dead colonies of bryozoan *Myriapora truncata*, polychaete tubes and most commonly on different algae. *Beania magellanica* was even recorded as epibiont on living ascidians *Microcosmus sulcatus* (COQUEBERT 1797) on the escarpment of Ćutin Island. In Grmac Cove, the species was abundant on the algae *Cystoseira* sp. Along the escarpment of Prvić Island, *B. magellanica* was very abundant, both on shaded and exposed microhabitats (NOVOSEL et al. 2004). Along the escarpment of Jabuka Islet, the species was abundant as epibiont within the shaded microhabitats of the calcareous algae *Lithophyllum grandiusculum* (MONT.). Furthermore, *B. magellanica* also occurred on the large colonies of *Pentapora fascialis* (PALLAS 1766) which grow under the influence of submarine freshwater springs, i.e. in the conditions of fluctuating, lower salinity (NOVOSEL et al. 2005). HAYWARD & MCKINNEY (2002) also found *B. magellanica* most frequently on biogenic substrata.

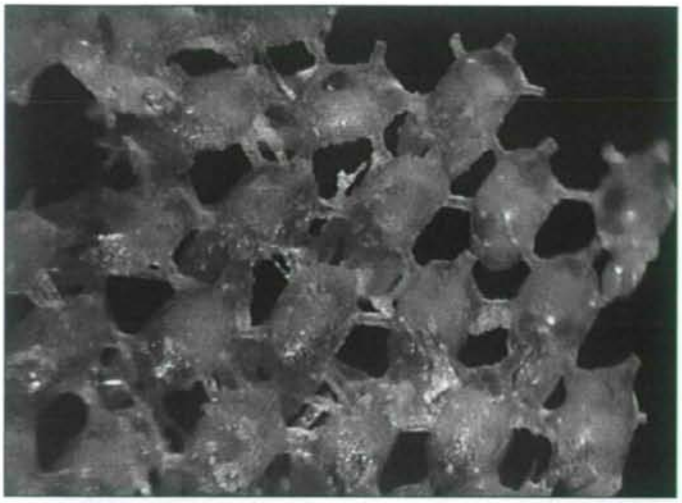


Fig. 3: *Beania magellanica.*

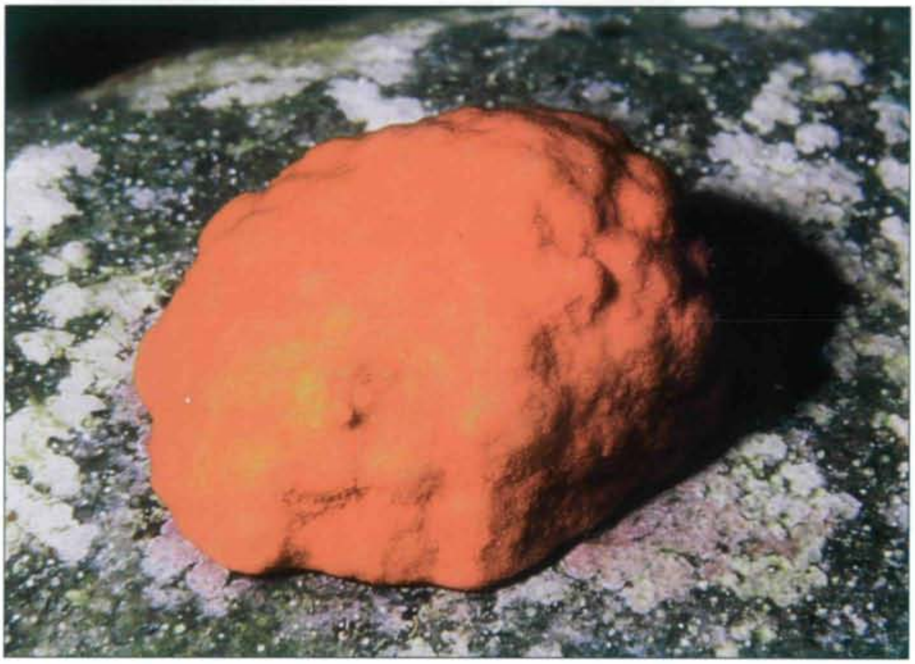


Fig. 4: *Schizomavella* sp.
Foto: J.-G. Harmelin.

Genus *Schizomavella* (Fig. 4) includes bryozoans with encrusting and often massive colonies, generally whitish or bright orange-coloured. Along the eastern Adriatic coast, 11 species of *Schizomavella* have been recorded till today (NOVOSEL & POŽAR-DOMAC 2001; HAYWARD & MCKINNEY 2002; NOVOSEL et al. 2004). Eight species have been recorded during this survey: *S. auriculata* (HASSALL 1842), *S. cornuta* (HELLER 1867), *S. discoidea* (BUSK 1859), *S. halimedae* (GAUTIER 1955), *S. hastata* (HINCKS 1862), *S. linearis* (HASSALL 1841), *S. mamillata* (HINCKS 1880) and *S. rudis* (MANZONI 1869). The most dominant species of *Schizomavella*, found at seven localities along the Adriatic coast, at depths from 5-40 m, were *S. cornuta* (4, 6, 8, 9, 16, 19, 21) and *S. discoidea* (1, 4, 10, 13, 16, 18, 21). *Schizomavella cornuta* was very abundant along the escarpments of the islands of Prvić

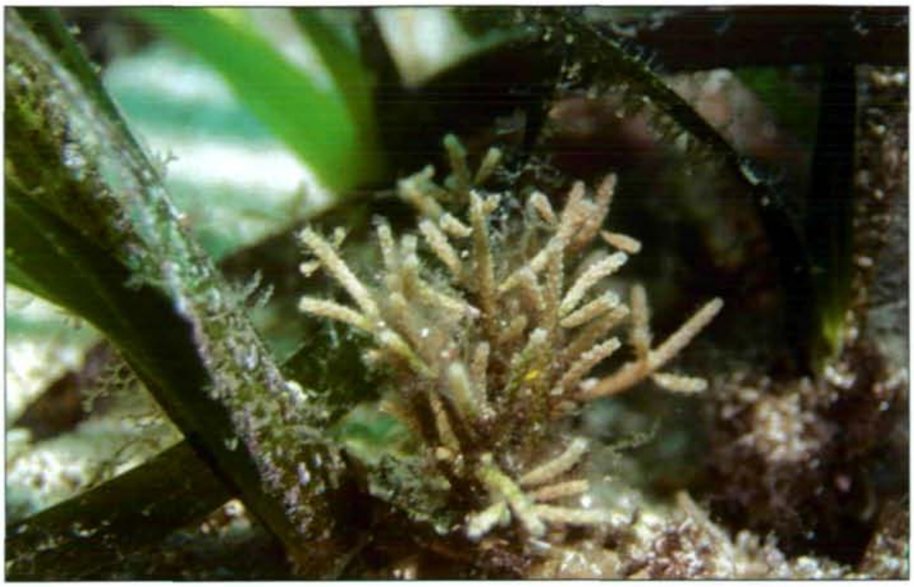
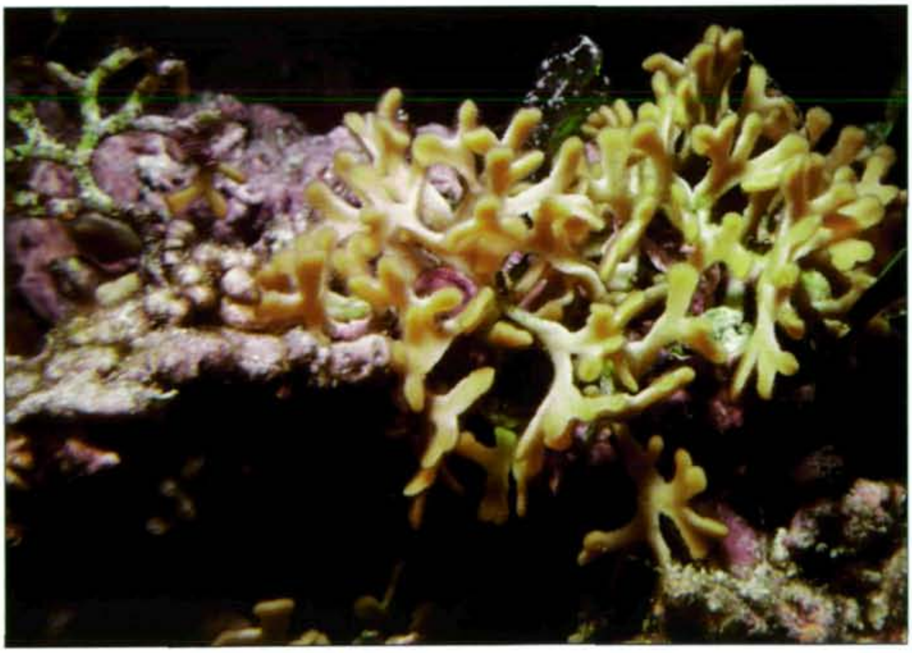


Fig. 5: *Margaretta cereoides.*

and Lastovo, both on sheltered and exposed microhabitats, but more commonly on last ones. It was found on different substrata: shells, algae and stones. *Schizomavella cornuta* appears to be tolerant to instable environment as it also grew on the stones inside the plume of submarine freshwater springs at Žrnovnica Cove, at 10 m depth (NOVOSEL et al. 2005). *Schizomavella discoidea* forms large, rounded and whitish colonies, mainly on the biogenic substrata. It was recorded the most frequently along the escarpments of the islands of Prvić and Jabuka and from the rocky slopes of Palagruža Island. These were followed by *S. auriculata* (2, 4, 13, 16, 18, 21) found at depths from 10-105 m and *S. linearis* (4, 8, 9, 13, 18, 21), found at depths from 5-45 m. Along the escarpment of Lastovo Island, *S. linearis* was very abundant, while on Ćutin Island some colonies were recorded from sheltered microhabitats, such as encrusting algae and stones, but also on ascidians *Microcosmus sulcatus*. On Prvić Island, colonies mainly grew on algae *Halimeda tuna* (ELLIS & SOLANDER) LAMOUROUX and on polychaete tubes and they were less abundant and much smaller than on Lastovo Island. *Schizomavella mamillata* was recorded from four localities (4, 13, 18, 21) from 10-45 m depth. Colonies were always massive and found in exposed microhabitats. On the islands of Prvić and Jabuka colonies were large and abundant, while on the islands of Palagruža and Lastovo they were very rare. *Schizomavella halimedae* was found very abundantly at the islands of Prvić and Lastovo from 20-40 m depth and *S. rudis* occurred at Lim Channel and Palagruža Island from 15-40 m depth, while *S. hastata* was recorded only once (16), at 30 m depth.

Fig. 6: *Schizotheca serratimargo.*
Foto: A. Novosel.



Margaretta cereoides (Fig. 5) is probably endemic to the Mediterranean (HAYWARD & MCKINNEY 2002). Colonies are erect, branching and jointed. In this survey, *M. cereoides* was recorded from five localities in the Central (10, 13, 15, 16, 18) and three in the South Adriatic (19, 20, 21). It is shallow water species, always found within very narrow depth range from 10-25 m. On Lastovo Island (Cape Struga), *M. cereoides* form dense meadow on the rocky plateau swept by strong currents, at 10 m depth. This species was also frequently found among the rhizomes of the seagrass *Posidonia oceanica* at Korčula Island and Pelješac Peninsula.

Schizotheca serratimargo (Fig. 6) is mainly distributed in the Mediterranean. Colonies are in most cases large, erect and orange-coloured, although it is not unusual to find encrusting, whitish-coloured forms as well. In this survey, *S. serratimargo* was recorded from two localities in the North (1, 9), five in the Central (11, 12, 13, 16, 18) and two in the South Adriatic (19, 21). *Schizotheca serratimargo* was mainly found in exposed microhabitats, from 10-50 m depth. Along the escarpments of the islands of Lastovo, Jabuka and Biševo, this species was very abundant, with large erect and rigid colonies. On the rocky slopes of Palagruža Island both erect and encrusting colonies were abundant and they were found as epibionts on other bryozoans such as *Reteporella* sp. and *Myriozoum truncatum* as well as on algae *Halimeda tuna*. The congeneric *Schizotheca fissa* (BUSK 1856) was recorded from the escarpment of Jabuka Islet at 20 m of depth and from the conglomerate taken up from 65 m of depth, in the vicinity of Palagruža Island. In both cases colonies were small and encrusting.

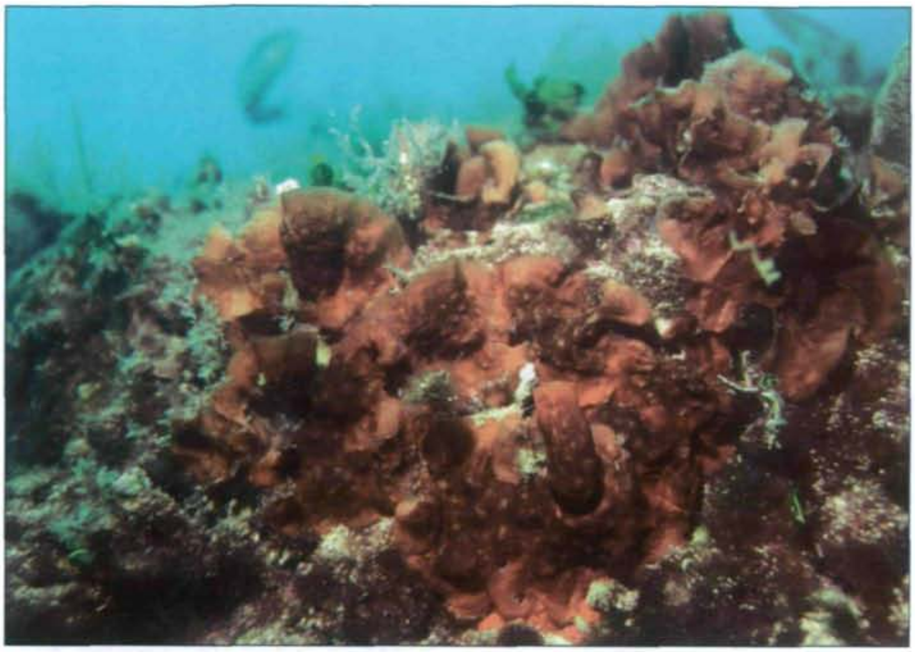


Fig. 7: *Schizobrachiella sanguinea*.

Schizobrachiella sanguinea (NORMAN 1868) (Fig. 7) is widely distributed through the Atlantic and the Mediterranean, encrusting organic carbonates in particular (HAYWARD & MCKINNEY 2002). It can form large irregular sheets coloured from bright orange to black. In this survey, it was recorded from five localities in the North (1, 2, 4, 6, 8), seven in the Central (10, 11, 12, 13, 15, 16, 18) and three in the South Adriatic (19, 21, 22). *Schizobrachiella sanguinea* commonly grows on shallow-water habitats exposed to light, strong waves and currents. Along the escarpments of the islands of Prvić and Jabuka, *S. sanguinea* was frequently found, but only within 3-20 m depth. On Lastovo Island, it was abundant, and found from 3-30 m depth. *Schizobrachiella sanguinea* can tolerate large fluctuations in salinity, as attested by its occurrence on substrates found in Žrnovnica Cove submarine freshwater springs' outlets. Furthermore, in the conditions of very strong currents, *S. sanguinea* can form unusually big sheets. Thus, on Korčula Island, colonies were about 60 cm^2 big at 15-30 m depth, covering vertical rocks in the narrow passage between small islands Badija and Lučnjak. At Mljet Island, in the narrow passages between the open sea and Veliko jezero and between Veliko jezero and Malo jezero, *S. sanguinea* form large erect colonies in the shallowest places (0.5-1.5 m depth) where currents are the strongest. But *S. sanguinea* was also frequently found on the rhizomes of seagrass *Posidonia oceanica* (Fig. 8), on the islands of Silba, Kornati, Korčula and Lastovo.

Smittina cervicornis (Fig. 9) is an Atlantic and Mediterranean species. Colonies are bright orange, erect, branching and rigid. In this survey, it was recorded from four localities in the North (4, 5, 8, 9), four in the Central (13, 15, 16, 18), and two in the South Adriatic (19, 21). *Smittina cervicornis* was always found on exposed microhabitats along the escarpments, at depths from 15-45 m. One white encrusting colony

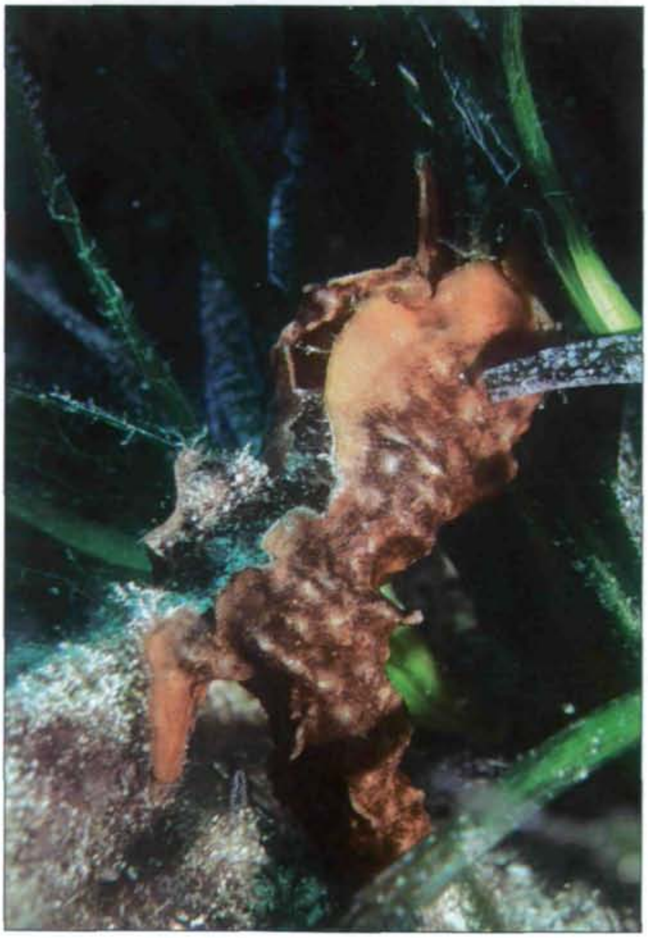


Fig. 8: *Schizobrachiella sanguinea* on the rhizomes of seagrass *Posidonia oceanica*.

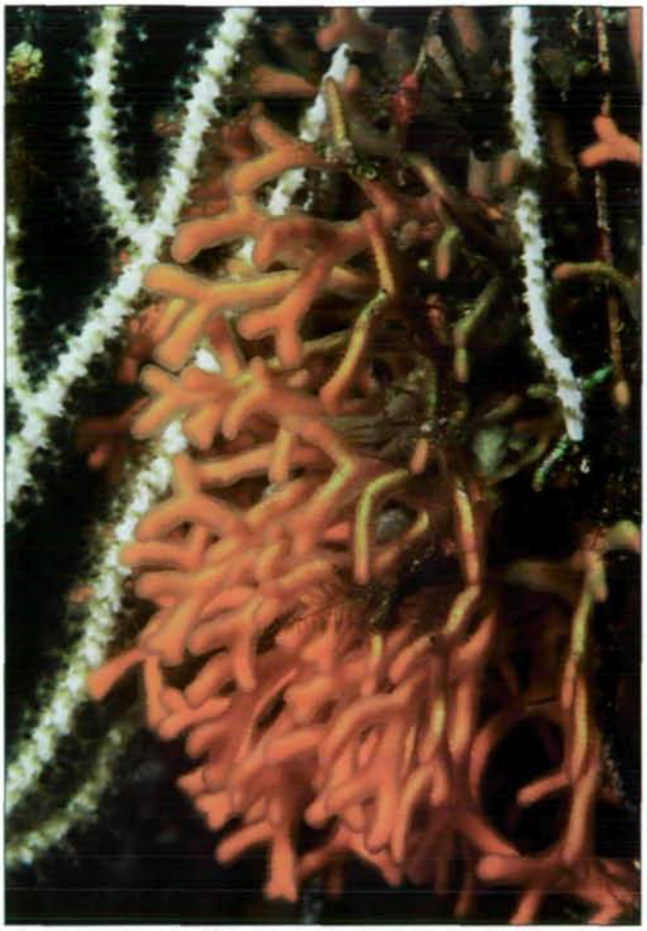


Fig. 9: *Smittina cervicornis*.
Foto: J.-G. Harmelin.

was found in marine cave on Biševo Island (Modra Špilja), at 25 m depth. In the North Adriatic, along the escarpment of Prvić Island, *S. cervicornis* was abundant, while in the South, on Lastovo Island, it was rare (NOVOSEL et al. 2004). *Smittina cervicornis* was frequently observed encrusted by the sponge belonging to genus *Halisarca* (HARMELIN et al. 1994).

Hornera frondiculata LAMOUROUX 1821 (Fig. 10) is probably Mediterranean species. Colonies are large, whitish, erect and branching. In this survey, *H. frondiculata* was found only four times, from three localities in the Central (11, 16, 18) and one in the South Adriatic (21). It was always found at 40 m depth, on the exposed microhabitats of sloping rocky bottoms.

The volcanic islet of Jabuka and nearby volcanic shoal offer habitat conditions which are particular in the Adriatic Sea. Namely, eastern Adriatic Sea is the sea of karst and all islands are built of karstic limestone with only four exceptions: Jabuka Islet and nearby shoal, Brusnik Islet and part of Vis Island near Komiža town (JURAČIĆ et al. 2004). Since magmatic rocks are much more resistant to biological abrasion, they are harder to colonize. This was evidenced by the absence of endolithic clionid sponges and of date shell *Lithophaga lithophaga* (LINNAEUS 1758) in the upper infralittoral zone (ZAVODNIK et al. 2000). Along the escarpment on the north, shadowed side of Jabuka Islet, bryozoan fauna were the most diverse. Small erect species *Scrupocellaria scrupea* BUSK 1852 (Fig. 11) dominated among all bryozoans, covering magmatic rock in the form of numerous small bushes. Toward the east coast, the dominant bryozoan along the escarpment was the encrusting species *Schizomavella discoidea*. In contrast to this, the bryozoan assemblages and dominant growth forms differ completely on the exposed south side. There, the escarpment resembled more to limestone escarpment (more crevices) and rigidly erect bryozoan species such as *Adeonella pallasii*, *Smittina cervicornis*, *Schizotheca serratimargo* and *Myriapora truncata* were dominant among large species. Round volcanic boulders from the bottom of the escarpments (50-60 m depth) were abundantly covered by sciaphilic encrusting bryozoan species like *Puellina* spp., *Microporella* spp. and discoidal *Patinella radiata* (AUDOUIN 1826).

3.2 Seagrass *Posidonia oceanica* meadows

The seagrass *Posidonia oceanica* meadows are in biological and economical sense the

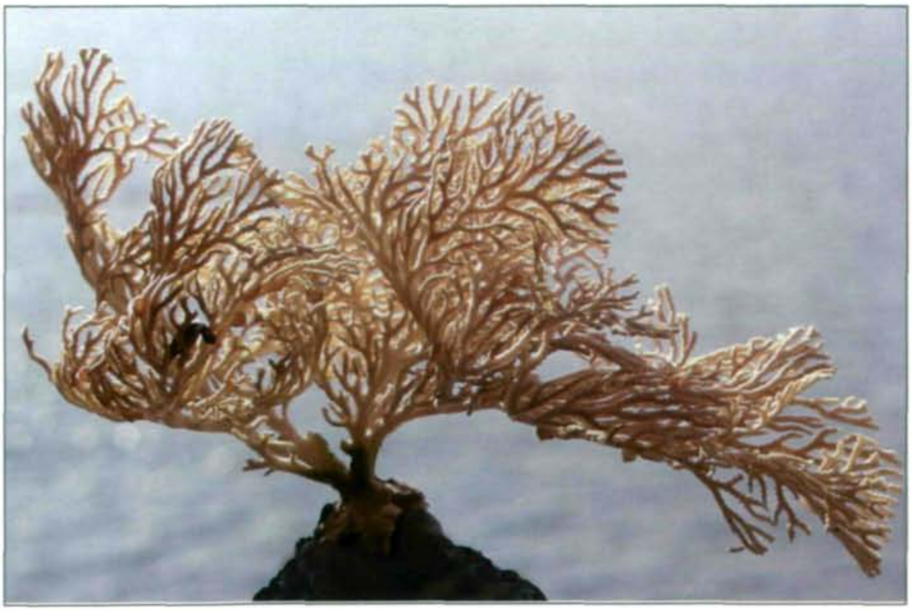


Fig. 10: *Hornera frondiculata*.
Foto: J.-G. Harmelin.

most valuable ecosystem of the Adriatic Sea and of the whole Mediterranean as well. Along the eastern coast of the Adriatic *P. oceanica* meadows are still numerous, dense and well-developed, although negative influence of human activities has a large impact on evolution and survival of this sensitive community (POŽAR-DOMAC et al. 2004). Many bryozoans are adapted to grow as epibionts on *P. oceanica* leaves or rhizomes, thus HARMELIN (1973b) recorded 90 bryozoan species among seagrass *P. oceanica* biocoenosis. Here some of the most dominant species are discussed.

Reptadeonella violacea (JOHNSTON 1847) (Fig. 12) is widely distributed through the Mediterranean, Atlantic Ocean and Pacific coasts of North America. Colonies are encrusting, deep purple when living (HAYWARD & MCKINNEY 2002). In this survey, it was found on four localities in the North (1, 2, 4, 9), three in the Central (13, 15, 18) and two in the South Adriatic (19, 21). *Reptadeonella violacea* is shallow water species, found between 5-30 m depth. Colonies of *R. violacea* were abundantly found both on leaves and rhizomes of seagrass *Posidonia oceanica*, but also as epiphytes on different algae.

Electra posidoniae GAUTIER 1957 (Fig. 13) is one of the most noticeable epibiont on *Posidonia oceanica* leaves. Colonies are in the form of long, white chains. In this survey, it was recorded from one locality in the North (9), one in the Central (10), and two in the South Adriatic (19, 20). It is shallow water species, found within narrow depth range between 2-7 m. In all localities, *Electra posidoniae* was very abundant. Another species of this genus, *E. pilosa* (LINNAEUS 1767) was recorded on Silba Island.

Calpensia nobilis (ESPER 1796) (Fig. 14) is shallow-water species, widely distributed through the Mediterranean. Colonies are widely spreading, multiserial, flat, light-coloured greyish-brown sheets, often exceeding 10 x 10 cm; through successive phases of regeneration and overgrowth may form thick cylinders and nodules on every kind of hard substratum. It was recorded from two localities in the North (1, 2), three in the Central (10, 13, 18), and one in the South Adriatic (20). It is common rhizome

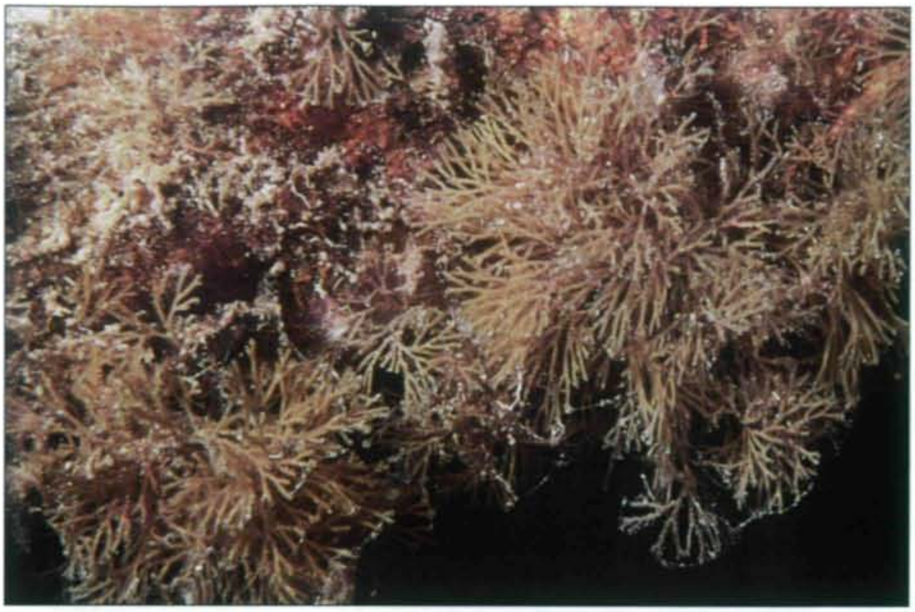


Fig. 11: *Scrupocellaria scrupea*. Foto: J.-G. Harmelin.

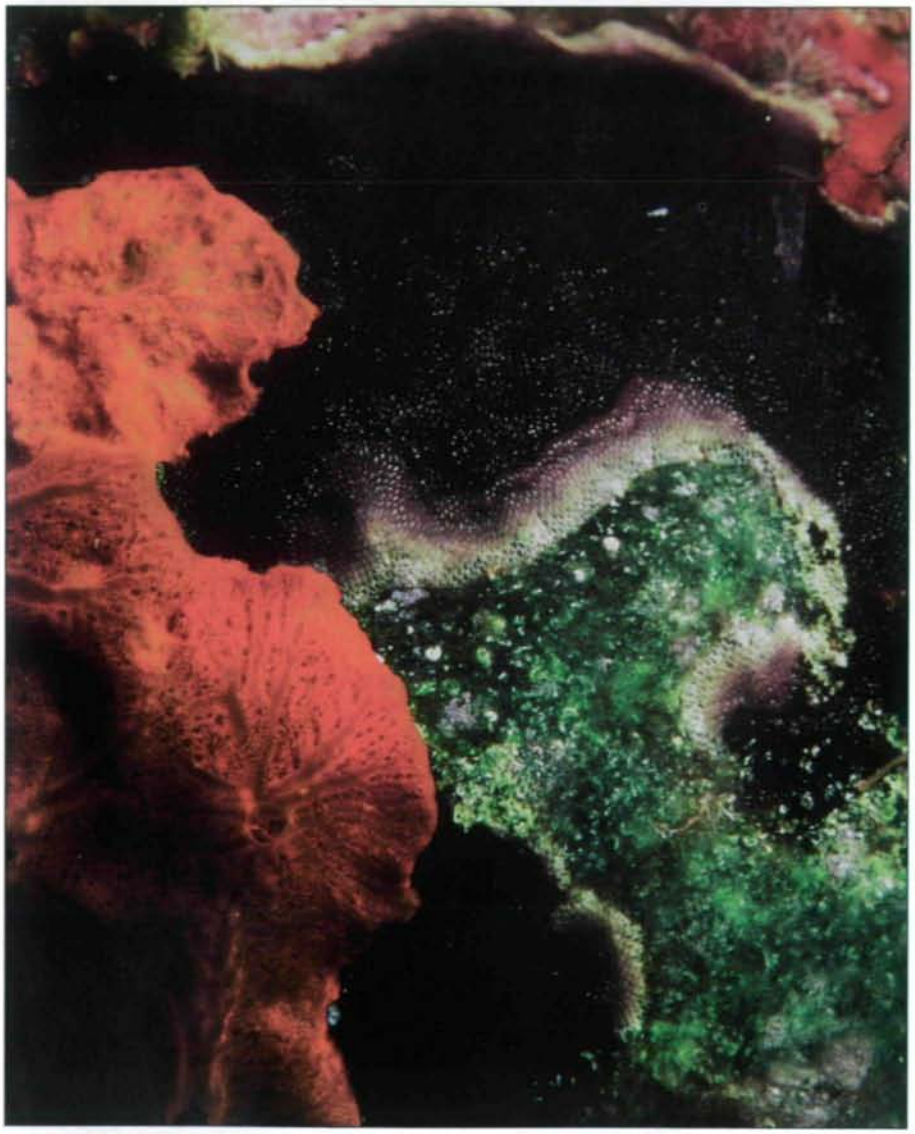


Fig. 12: *Reptadeonella violacea*. Foto: J.-G. Harmelin.

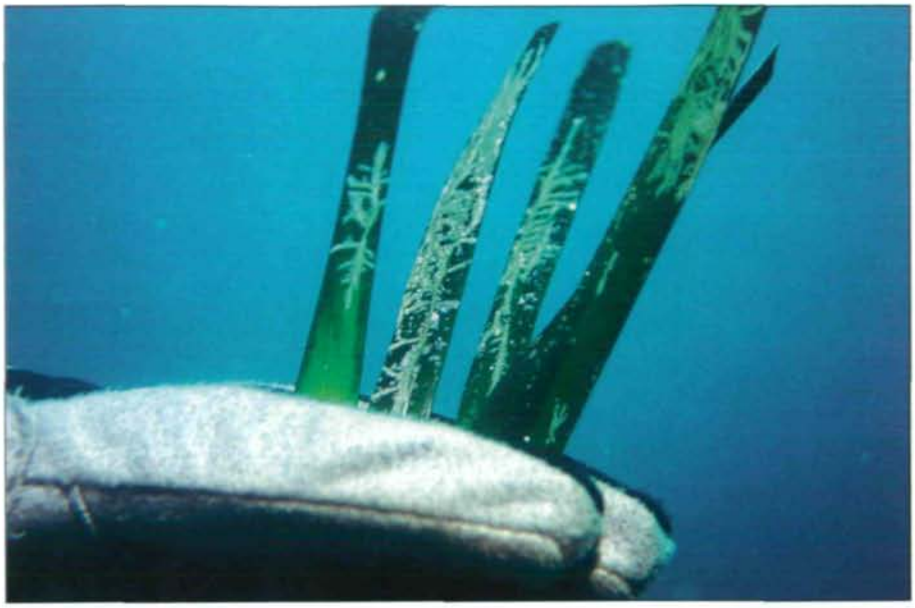


Fig. 13: *Electra posidoniae*. Foto: A. Novosel.

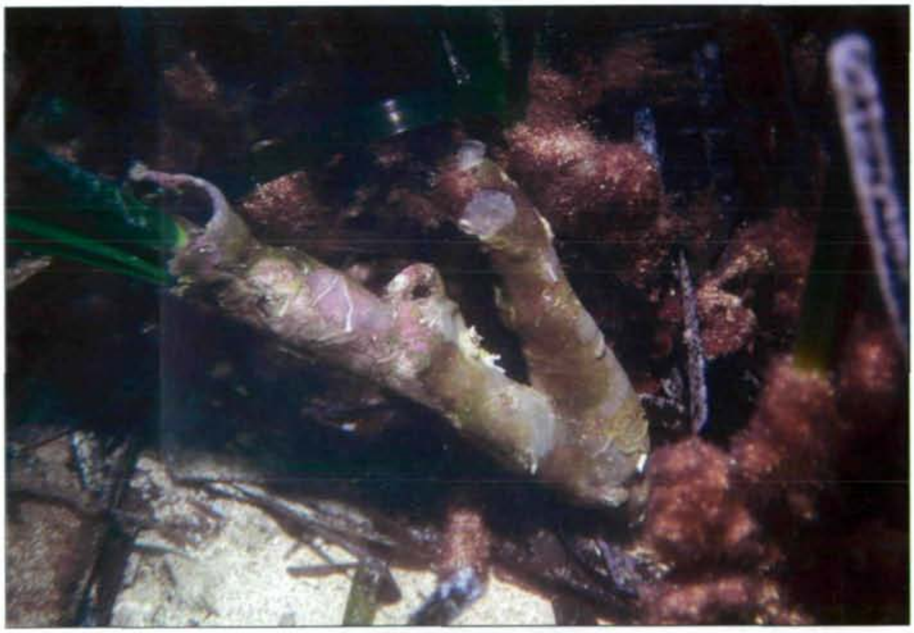


Fig. 14: *Calpensia nobilis*. Foto: A. Novosel.

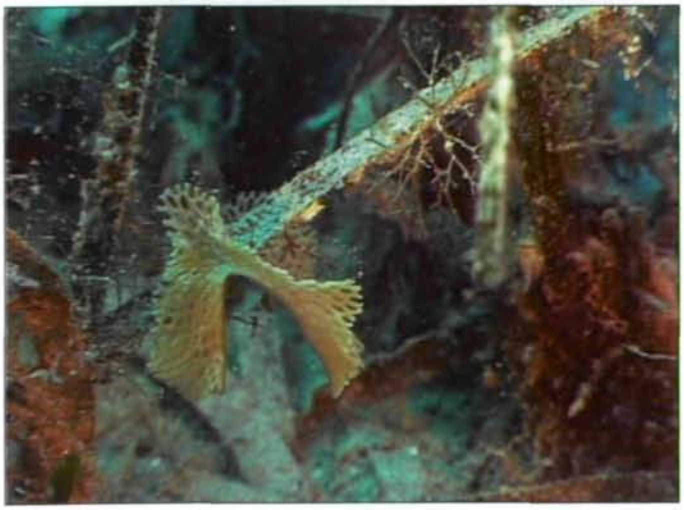


Fig. 15: *Reteporella* sp. on the leaf of seagrass *Posidonia oceanica*. Foto: A. Novosel.

epiphyte of seagrass *Posidonia oceanica*. ROMERO COLMENERO & SÁNCHEZ LIZASO (1999) found out that the rhizome encrusted with *Calpensia nobilis* grew significantly faster. *Calpensia nobilis* was also recorded on the glass substratum in the North Adriatic, and as epibiont on algae *Halimeda tuna* in the South. It was found within the depth range from 10-35 m.

Genus *Reteporella* (Fig. 15) includes bryozoans with delicate fenestrate colonies. Colonies found in the biocoenosis of seagrass *Posidonia oceanica* were mainly pale orange to whitish-coloured and grew as epiphytes on the *Posidonia* leaves. Within densely and well-developed *P. oceanica* meadows at the islands of Dugi otok and Kornati, both in Central Adriatic, *Reteporella* sp. colonies were present on almost every leaf, within depth range from 5-30 m. Interestingly, in *Posidonia* meadow on Dugi otok Island, numerous *Reteporella* sp. colonies grew on the top of leaves in deeper sheltered zones, at depth between 20-30 m. Shallower, colonies were found more closer to the base of leaves, while at 5 m depth *Reteporella* sp. was only found on the rhizomes, again as very abundant species.

Patinella radiata (Fig. 16) is distributed in the Mediterranean and Atlantic. Colonies are small, discoidal and encrusting. It was recorded from two localities in the North (4, 8), two in the Central (13, 18) and one in the South Adriatic (21). In *Posidonia* meadows *P. radiata* was found both on leaves and rhizomes. Beside *Posidonia* epiphyte it also occur on many different algae, such as *Flabellia petiolata* (TURRA) NIZAMUDDIN, *Halimeda tuna* and *Lithophyllum grandiusculum*. *Patinella radiata* was also recorded as epibiont on dead colonies of other bryozoans, such as *Myriapora truncata*, *Scrupocellaria* sp. and *S. serratimargo*, as well as on stones and shells, at depth range between 5-65 m.

Tubulipora liliacea (PALLAS 1766) (Fig. 17) occur in the Mediterranean and Atlantic Ocean. Colonies are encrusting or semierect. The variations in shape and robustness of colonies are related to the physical environment (HARMELIN 1976). In this survey, it was found on two localities in the North (4, 8), five in the Central (10, 13, 15, 16, 18), and one in the South Adriatic (21). Recorded depth range was between 8-105 m. *Tubulipora liliacea* is sciaphilic species, abundant on the *Posidonia* rhizomes but also along the escarpments, where it was mainly found growing as epiphyte on different algae (*Codium adhaerens* C. AGARDH., *Flabellia petiolata*, *Halimeda tuna*, *Peyssonellia* sp., *Corallina* sp., *Pseudolithophyllum expansum* (PHIL.) LEMOINE). Another species, *Tubulipora aperta* (HARMER 1898), was found in the South on Lastovo Island, on exposed microhabitats between 15-20 m depth.

3.3 Marine caves

The heavily karstified eastern coast of the Adriatic Sea is characterized by numerous submarine caves, cavities and crevices. Cave fauna of the Adriatic Sea was surveyed by RIEDL (1966), but bryozoan inhabitants are scarcely known, although cryptic habitats (large submarine caves to smallest cavities) shelter a large part of the bryozoan fauna occurring in the coastal zone. There, local assemblages are shaped by strong environmental gradients such as light, temperature, water circulation and food resources (HARMELIN 2000).

Genus *Celleporina* (Fig. 18) includes bryozoans with spherical, rigid and whitish-coloured colonies. Most of the species are sciaphilic, although some were found on more or less exposed habitats. Along the eastern Adriatic coast, seven species of *Celleporina* have been recorded till today (NOVOSEL & POŽAR-DOMAC 2001; HAYWARD & MCKINNEY 2002; NOVOSEL et al. 2004). Three species have been recorded in sheltered habitats of the semi-cave and cave biocoenoses during this survey: *C. caminata* (WATERS 1879), *C. canariensis* ARISTEGUI 1989 and *C. hassallii* (JOHNSTON 1847), while two have been recorded from more exposed habitats: *C. decipiens* HAYWARD 1976 and *C. lucida* (HINCKS 1880). *Celleporina caminata* is probably endemic to the Mediterranean region (HAYWARD & MCKINNEY 2002). In this survey, it was found at eight localities, at depth from 10-65 m. It was found on two localities in the North (4, 9), four in the Central (13, 14, 16, 18), and two in the South Adriatic (19, 21). One of the most dominant celleporiform species of the

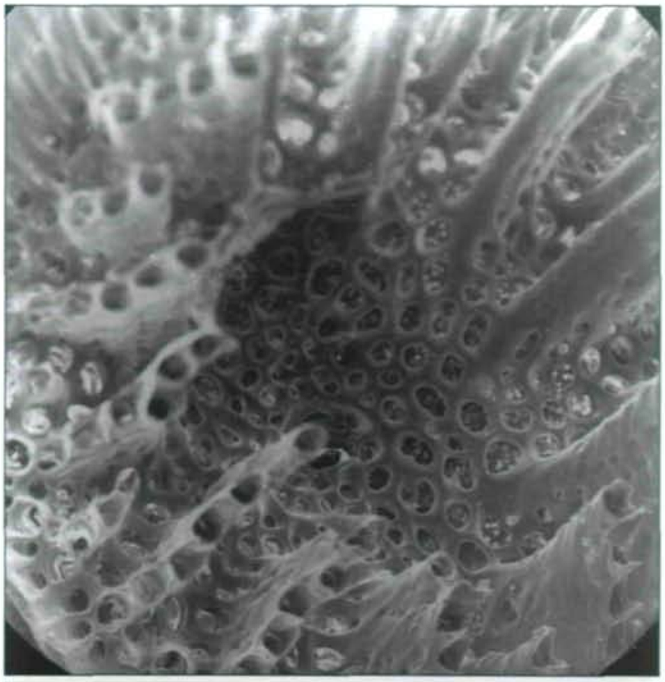


Fig. 16: *Patinella radiata*.

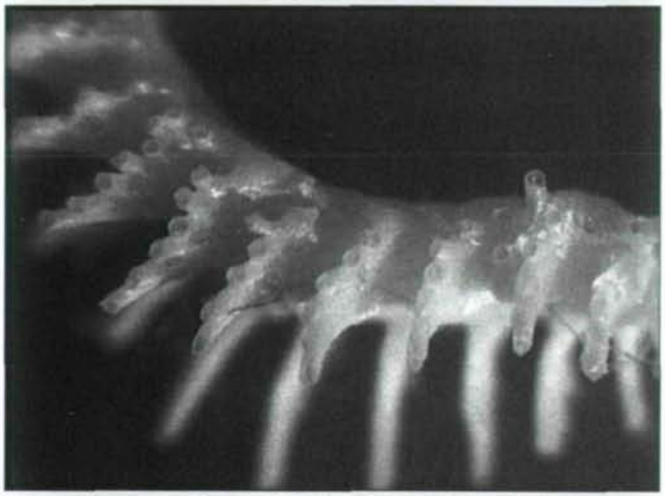


Fig. 17: *Tubulipora liliacea*.

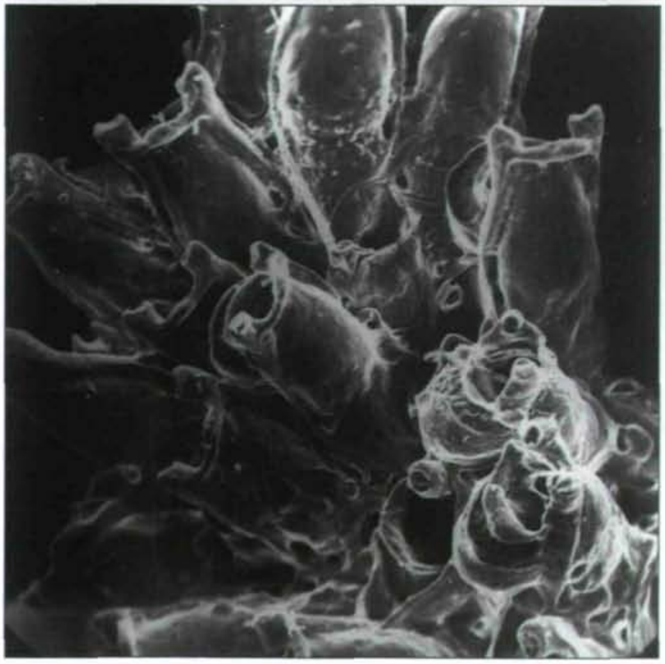


Fig. 18: *Celleporina decipiens*.

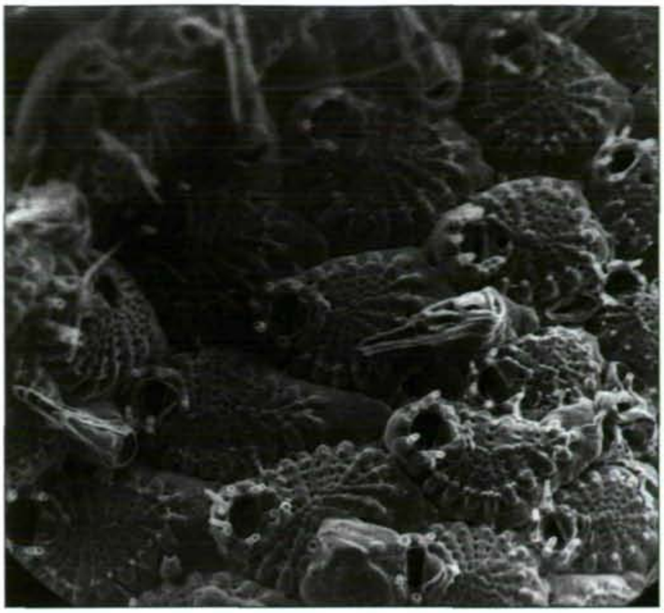
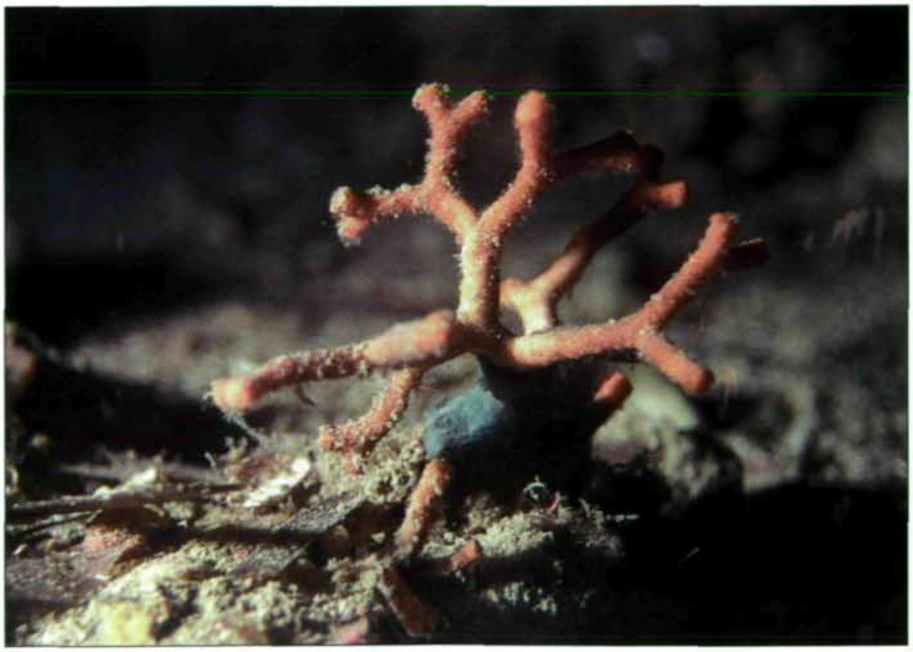


Fig. 19: *Puellina hincksi.*

semi-cave and cave biocoenoses was *C. caminata*. This species was found occupying the whole wall from 6 to 10 m depth and about 20 m wide in the cave Modra Špilja on Biševo Island. It was frequently found as semi-cave or overhang dweller in cavities along the escarpments of the islands of Prvić, Jabuka and Lastovo. On Palagruža Island, *C. caminata* was recorded in numerous cavities, on sandy-detritic bottom growing on the following dead bryozoans: *Adeonella pallasii, Scrupocellaria scrupea, Margaretta cereodies, Myriapora truncata* and *Reteporella* sp. *Celleporina canariensis* is distributed in the Mediterranean and Atlantic. It was found only in the Central Adriatic, on volcanic Jabuka Islet, between 15-25 m depth. One colony was found growing on the dead bryozoan *Smittina cervicornis*, while others were found on different small conglomerates. *Celleporina decipiens* is Atlantic species with rare findings in the Mediterranean (HAYWARD & RYLAND 1999). It was found only in the North Adriatic, on Prvić Island, at narrow depth range between 5-10 m. It seems this species is not sciaphilic, since it was found within the biocoenosis of photophilic algae, as epiphyte on algae *Cystoseira schiffneri* HAMEL. *Cystoseira hassallii* is widespread in the Mediterranean and Atlantic Ocean. In this survey, it was found at nine localities, from 10-65 m depth. These were four localities in the North (4, 6, 8, 9), four in the Central (10, 13, 14, 18) and one in the South Adriatic (21). It occurred in cryptic habitats, mostly as overhang dweller of calcareous algae and on the stones inside cavities. It was also found inside the plume of submarine freshwater springs and on leaves of the seagrass *Posidonia oceanica*. *Cystoseira lucida* is probably Mediterranean species. In this survey, it was recorded from five localities, with depth range from 10-65 m. There were two findings in the North (4, 8) and three in the Central Adriatic (13, 16, 18). *Cystoseira lucida* seems not to be sciaphilic species, since it was found on exposed habitats, mainly as epiphyte on algae (*Halimeda tuna* and *Flabellia petiolata*) as well as on polychaete tubes.

Fig. 20: *Myriapora truncata.*
Foto: A. Novosel.



Genus *Puellina* (Fig. 19) includes cryptic bryozoans with encrusting, whitish-coloured colonies. Along the eastern Adriatic coast, seven species of *Puellina* have been recorded till today (NOVOSEL & POŽAR-DOMAC 2001; HAYWARD & MCKINNEY 2002; NOVOSEL et al. 2004). All of them have been found during this survey: *P. gattyae* (LANDSBOROUGH 1852), *P. hincksi* (FRIEDL 1917), *P. innominata* (COUCH 1844), *P. pedunculata* GAUTIER 1956, *P. picardi* HARMELIN 1988, *P. radiata* (MOLL 1803) and *P. venusta* CANU & BASSLER 1925. *Puellina gattyae* is distributed in the Mediterranean and Atlantic. In this survey, it was found at two localities in the North (4, 9) and two in the Central Adriatic (13, 16). Recorded depth was from 5-30 m. Colonies were always found as epiphytes on algae and seagrass *Posidonia oceanica* leaves. *Puellina hincksi* is Mediterranean

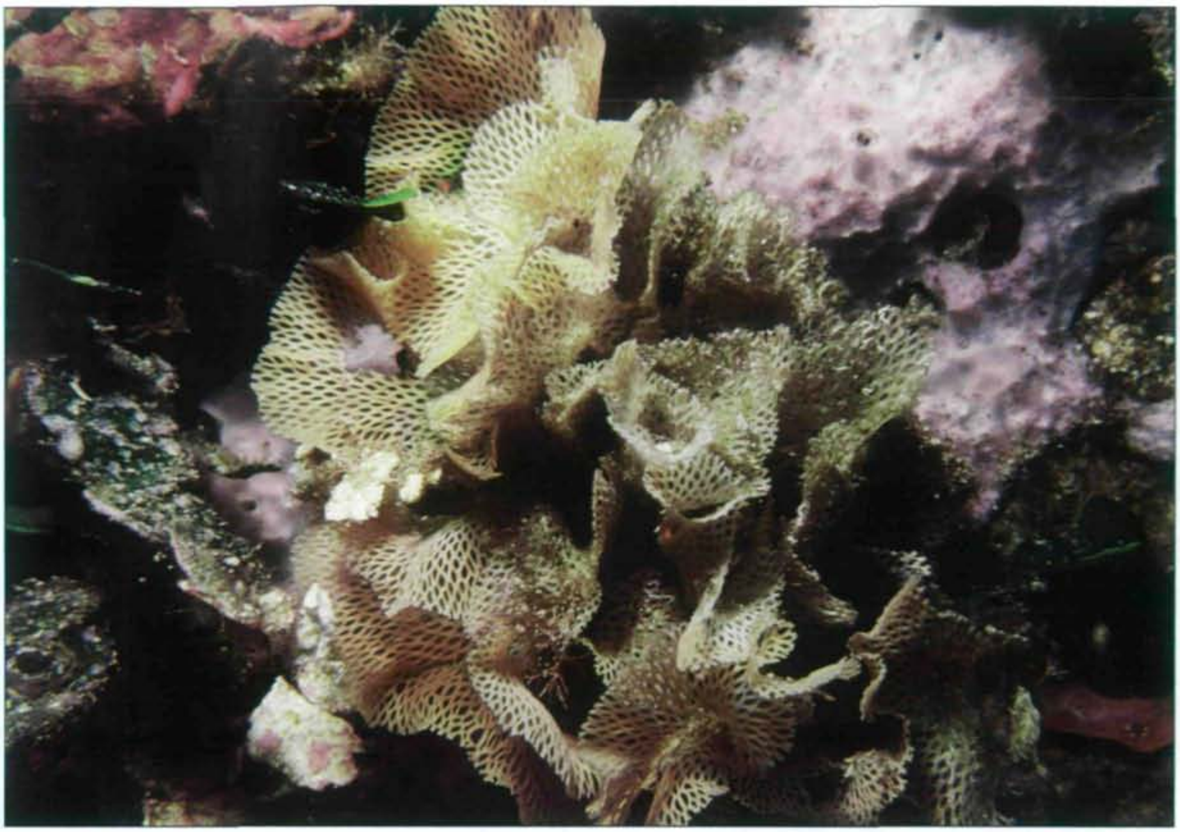


Fig. 21: *Reteporella* sp. 1. Foto: A. Novosel.

species. In this survey, it was found at two localities in the North (4, 9) and one in the South Adriatic (21). Recorded depth was from 20-40 m. In relation to other *Puellina* species, colonies were large. *Puellina hincksi* was mainly found encrusting dead shells, but also corals, algae, stones and ascidian *Microcosmus sulcatus*. *Puellina innominata* is Atlantic and Mediterranean species. In this survey, it was found at three localities in the North (4, 8, 9) and one in the Central Adriatic (16). Recorded depth was from 10-40 m. Colonies were found encrusting sheltered parts of dead shells, calcareous algae and stones. *Puellina pedunculata* is endemic to the Mediterranean. It is always sciaphilic species (HARMELIN 1970). In this survey, it was found at one locality in the North (4), one in the Central (10) and one in the South Adriatic (21). On Prvić Island, species was rare, found from 35-40 m depth, on stones in crevices along the escarpment. On Lastovo Island, species was abundant, found from 25-35 m depth. There, colonies were very small and always encrusted sheltered parts of calcareous algae. On Silba Island, *P. pedunculata* was recorded at 5 m depth, on the lower parts of seagrass *Posidonia oceanica* leaves. *Puellina picardi* is Mediterranean species. In this survey it was found only in the North Adriatic, on Prvić Island where it was rare. Colonies were found from 25-30 m depth, on sheltered parts of calcareous algae. *Puellina radiata* is Mediterranean species. It is one of the most frequent bryozoan epibiont on scleractinians (HARMELIN 1990). In this survey, *P. radiata* was found at three localities in the North (4, 8, 9), one in the Central (18) and one in the South Adriatic (21). It was recorded from 10-50 m depth, mostly encrusting calcareous algae. *Puellina venusta* is distributed in the Mediterranean and Atlantic. In this survey, it was found only in the South Adriatic, on Lastovo Island. Colonies were rare and found along the escarpment encrusting sheltered parts of calcareous algae, in the narrow depth range between 30-35 m.

Myriapora truncata (Fig. 20) is a Mediterranean species. Colonies are large, erect, rigid and bright red-coloured. In this survey, *M. truncata* was found at three localities in the North (4, 5, 9), four in the Central (10, 11, 13, 18) and two in the South Adriatic (19, 21). It was found from 10-50 m depth as abundant in all sciaphilic habitats, especially on the floors of semi-caves

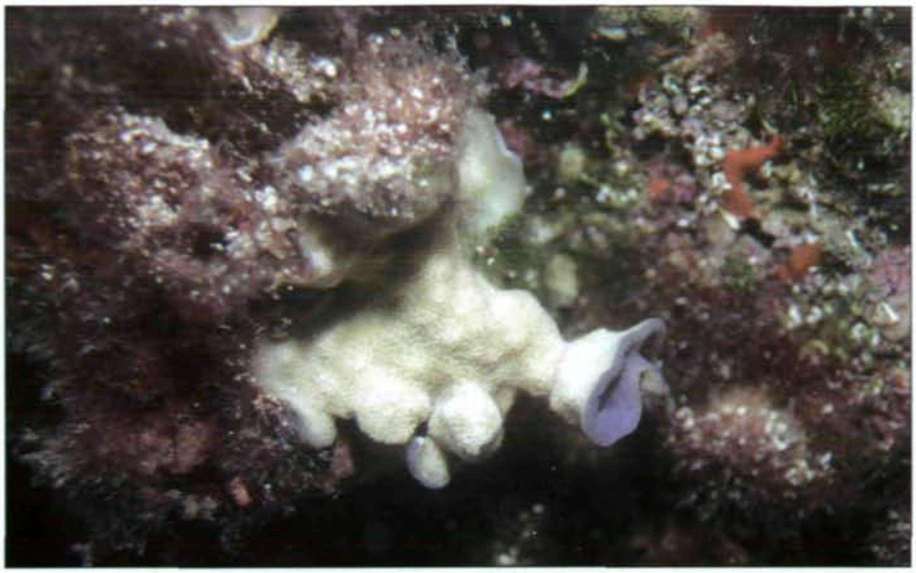


Fig. 22: *Rhynchozoon* sp.

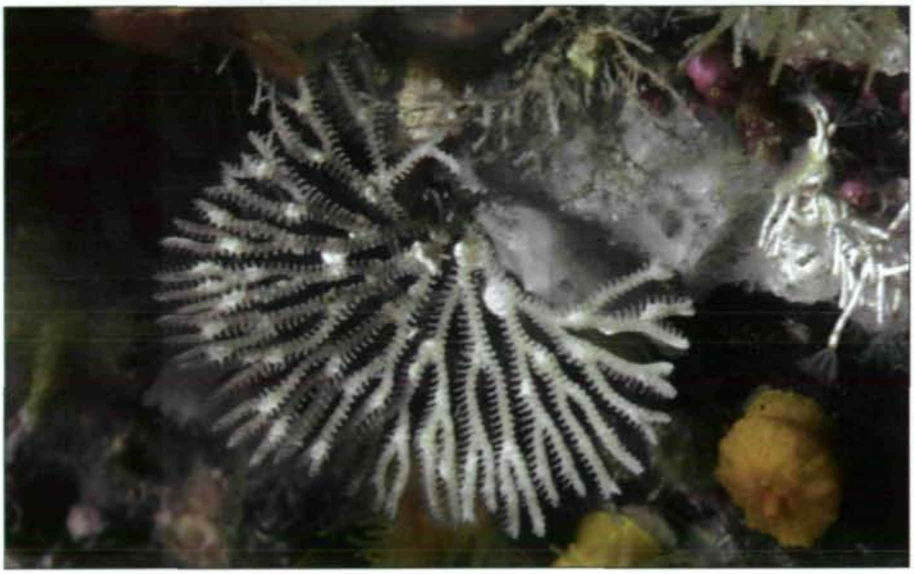


Fig. 23: *Idmidronea atlantica*. Foto: J.-G. Harmelin.

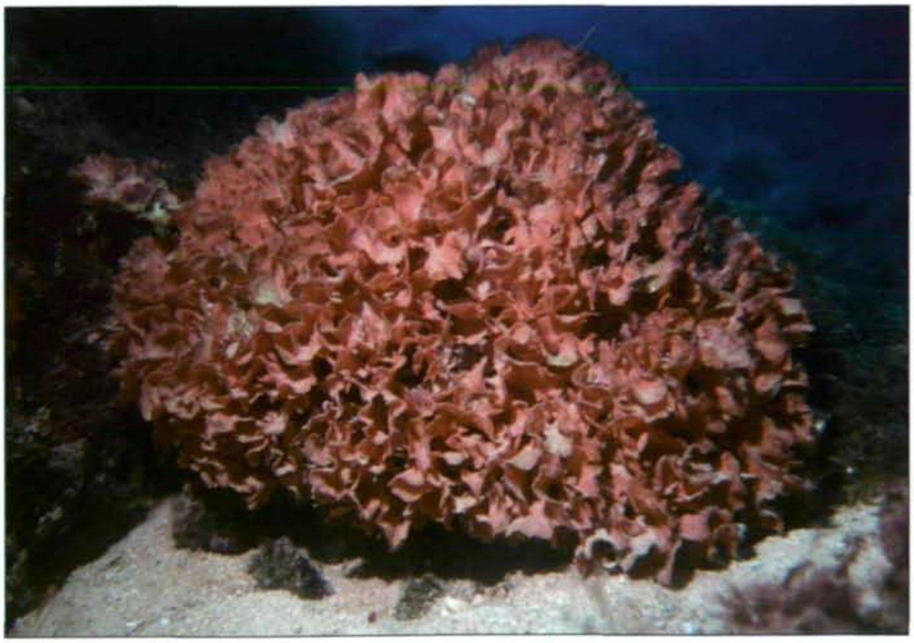


Fig. 24: *Pentapora fascialis*.
Foto: A. Novosel.

and in the entrances of caves.

Genus *Reteporella* (Fig. 21) includes bryozoans with delicate fenestrate colonies. In this survey, colonies found in the biocoenoses of semi-caves and caves were mainly pale red to whitish-coloured and grew in cavities and crevices on the rocky bottoms, from 10-65 m depth. Species of *Reteporella* were found at two localities in the North (4, 5), five in the Central (11, 13, 15, 16, 18) and two in the South Adriatic (19, 21). Colonies of *Reteporella* sp. were particularly abundant along the escarpment of Dugi otok Island (Vele stijene). There, under 20 m depth and deeper, they were found in almost every cavity and many colonies were fused together making large fenestrate fan. On Palagruža Island, *R. septentrionalis* HARMER 1933 was recorded under 20 m depth, in sheltered habitats under rocks, but also on algae *Halimeda tuna*.

The genus *Rhynchozoon* (Fig. 22) includes bryozoans with encrusting, cream-coloured to tan and massive nodular colonies (HAYWARD & MCKINNEY 2002). In this survey, colonies found in the biocoenosis of semi-caves and caves were found from 10-50 m depth. Species of *Rhynchozoon* were found at three localities in the North (2, 4, 9), four in the Central (10, 13, 16, 18) and two in the South Adriatic (19, 21). Colonies of *Rhynchozoon* sp. were particularly large and abundant on overhangs along the escarpment of Lastovo Island.

Idmidronea atlantica (FORBES in JOHNSTON 1847) (Fig. 23) occur in the Mediterranean and Atlantic Ocean. Colonies are white, more or less erect. In this survey, it was recorded from two localities in the North (4, 8) and one in the Central Adriatic (18). *Idmidronea atlantica* was found between 10-105 m depth. At Prvić Island, it was mainly found as epiphyte on algae, while on Palagruža Island it was abundant on algae *Flabellia petiolata*, *Halimeda tuna* and *Peyssonellia* sp., but also as epibiont on other bryozoans such as *Schizobrachiella san-*

guinea and *Reteporella* sp. *Idmidronea atlantica* is sciaphilic species and its ecological distribution is from the precoralligenous biocoenosis to the semiobscure caves. Within the wide range of habitats, *I. atlantica* presents strongly marked zoarial polymorphism (Harmelin 1973a).

3.4 Soft bottoms

Soft or mobile bottoms are generally considered as habitats of lower bryozoan diversity. However, if strong and steady bottom currents are present any small particle of rock or dead shell may be excellent solid substrata for the bryozoan colony.

Pentapora fascialis (Fig. 24) is distributed in the Mediterranean and Atlantic. It is the largest and most conspicuous calcified bryozoan in the Adriatic Sea. It is characteristic for current-swept coarse bottoms. Colonies are red, erect, and rigid and heavily calcified (Hayward & McKinney 2002). In this survey, *P. fascialis* was found at four localities in the North (5, 6, 7, 8), two in the Central (15, 18) and one in the South Adriatic (19). Along the coast of the Velebit Channel in the North Adriatic, where Sv. Juraj and coves of Žrnovnica, Ždralova and Grmac have been surveyed, large colonies of *P. fascialis* were particularly abundant. There, *P. fascialis* colonies grew only in the vicinity of submarine freshwater springs (Fig. 25) on sandy-detritic bottom, between 1-35 m depth (Cocito et al. 2004; Novosel et al. 2005). In the Central Adriatic, only small colonies were observed, within the depth range from 20-50 m. But large colonies of *P. fascialis* were also observed in the South on Korčula Island (between 25-35 m depth) where none of the submarine freshwater spring was present, but the location was narrow passage between small islands Badija and Lučnjak characterized by constant and very strong currents. There, large and numerous colonies of *P. fascialis* grew together with unusually big sheets of bryozoan *Schizobrachiella sanguinea*.

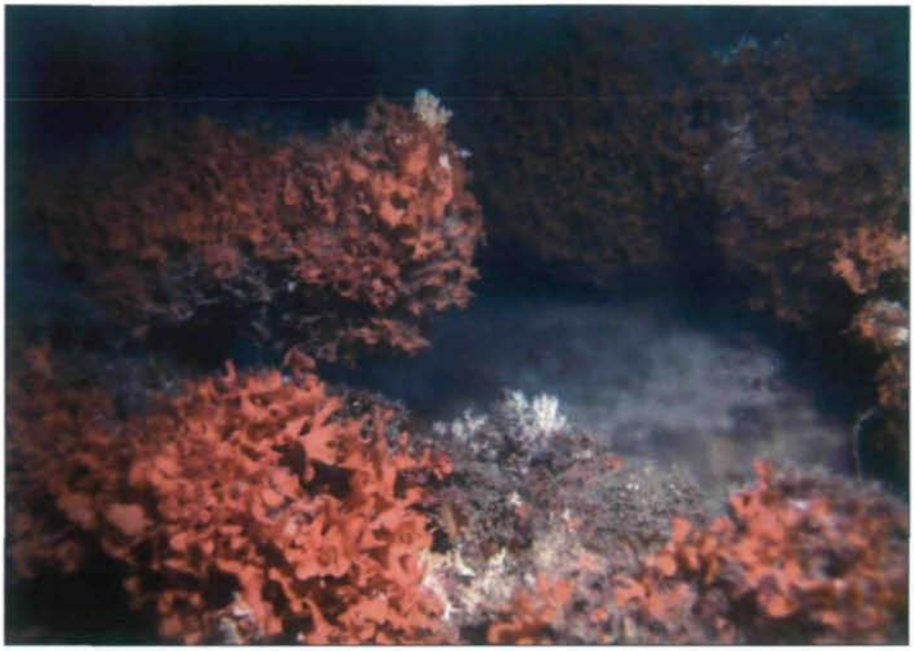
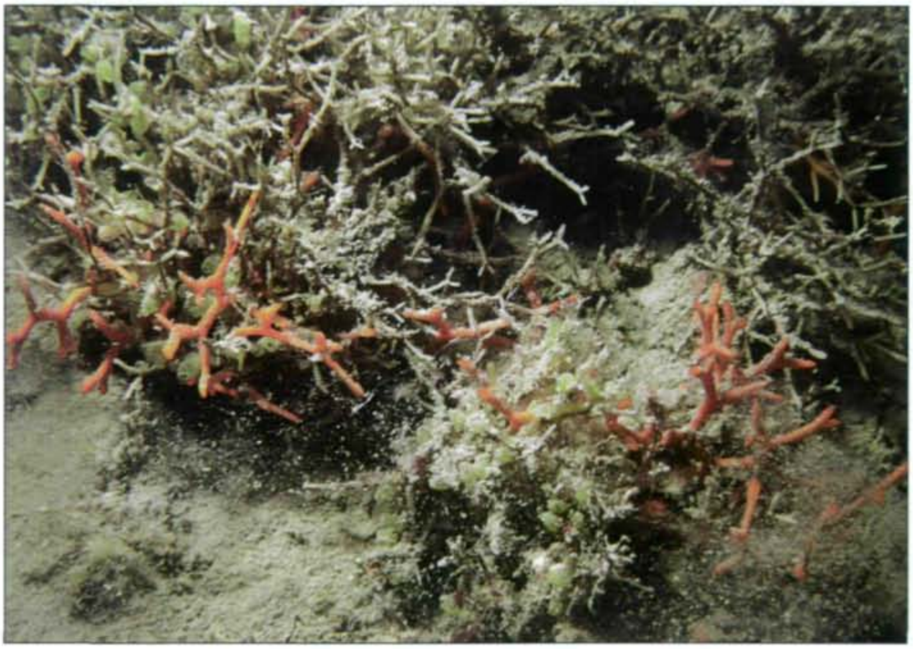


Fig. 25: *Pentapora fascialis* colonies in the vicinity of submarine freshwater springs. Foto: A. Novosel.

The genus *Cellaria* (Fig. 26) includes bryozoans with erect branching colonies. Colonies are attached to the substratum by tubular rhizoids (Hayward & McKinney 2002). Along the eastern Adriatic coast, three species of *Cellaria* have been recorded till today (Novosel & Požar-Domac 2001). Two species have been recorded during this survey: *C. fistulosa* and *C. salicornioides*. *Cellaria fistulosa* was recorded only at one locality in the North Adriatic (3), while *C. salicornioides* was recorded from three localities in the North (3, 4, 8), one in the Central (18) and one in the South Adriatic (21). All colonies were found between 10-30 m depth. One of the most famous bryozoan assemblages in the North Adriatic is a dense meadow of *C. fistulosa* and *C. salicornioides*, in the vicinity of Rovinj, at 35 m depth. This bryozoan meadow covers an area greater than 100 x 100 m, west of Ban-

Fig. 26: *Cellaria fistulosa* and *C. salicornioides* meadow (with orange-coloured *Adeonella pallassii* colonies). Foto: A. Novosel.



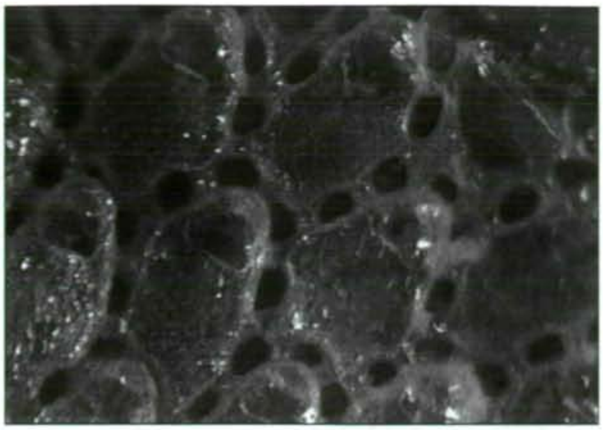


Fig. 27: *Mollia circumcincta*.

jole Island. The meadow is located on a sediment-floored plain swept by strong bottom currents. 58 species of marine animals has been found as epibionts on *Cellaria* branches (McKinney & Jaklin 2000). Other erect, rigid bryozoans that intergrow with *Cellaria* were: *Pentapora fascialis*, *Adeonella pallasii* and *Reteporella septentrionalis* (McKinney & Jaklin 2001). All other findings of *Cellaria salicornioides* in the Adriatic refer to small and individual colonies.

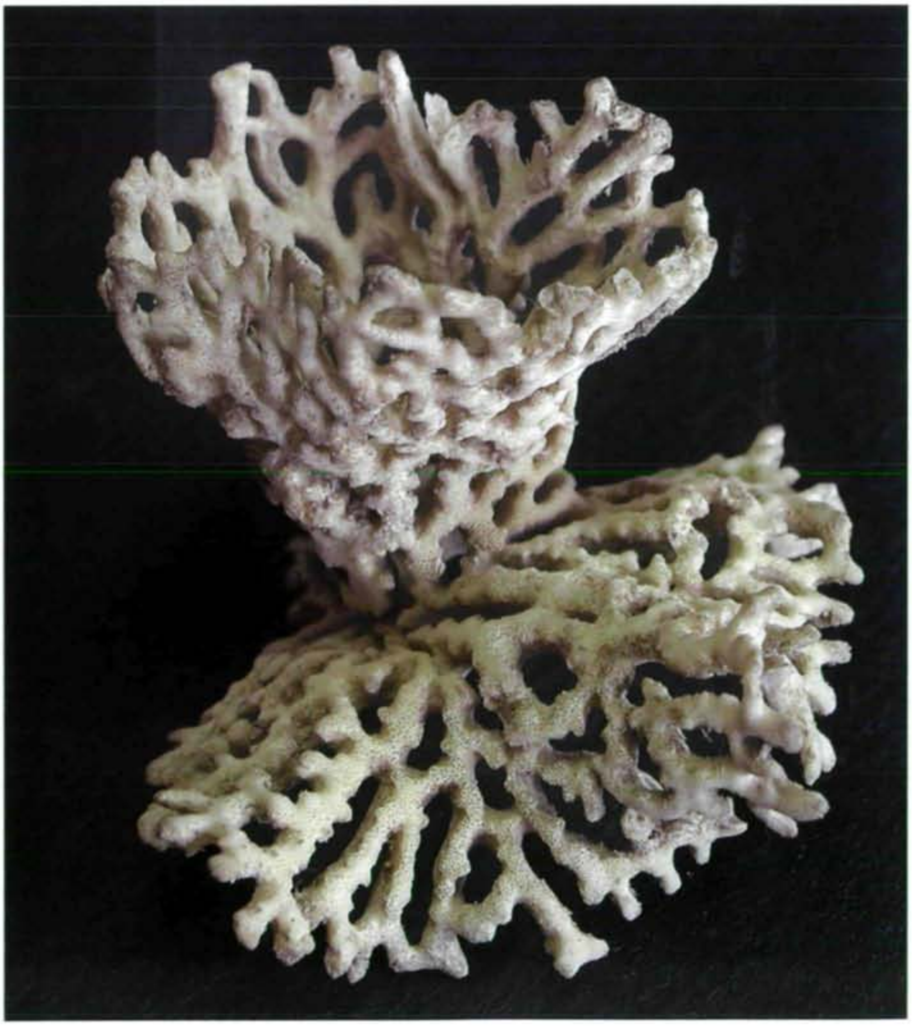


Fig. 28: *Frondipora verrucosa*.
Foto: J.-G. Harmelin.

Genus *Mollia* (Fig. 27) includes bryozoans with slender, encrusting colonies. Along the eastern Adriatic coast, two species of *Mollia* have been recorded till today (Novosel & Požar-Domac 2001), and both of them were recorded during this survey: M. *circumcincta* (Heller 1867) and M. *patellaria* (Moll 1816). *Mollia circumcincta* is probably a Mediterranean species. This species was first described from the Adriatic and has been reported from very few additional localities. It seems to be particularly abundant in the Adriatic Sea (Hayward & McKinney 2002). Colonies are usually small and membraniporiform. In this survey, it was recorded from three localities in the North (4, 8, 9), two in the Central (13, 16) and three in the South Adriatic (19, 21, 22). Colonies were found between 5-35 m depth. *Mollia circumcincta* was mostly found on sheltered habitats of small peaces of shells or rocks on sandy-detritic bottoms, but also as epiphyte on different algae. On Mljet Island (Veliko Jezero, between 5-15 m depth), this species was one of very few bryozoans found as epibiont on the reef of colonial scleractinian coral *Cladocora caespitosa* (Linnaeus 1767). *Mollia patellaria* is Mediterranean species. Colonies are small and creeping. In this survey, it was recorded from three localities in the North (4, 8, 9), three in the Central (13, 16, 18) and one in the South Adriatic (21). Colonies were found between 3-40 m depth. It was mainly found as sheets on the exposed parts of different algae on coarse bottoms, but also along the escarpments, on the sheltered part of calcareous algae and stones.

Frondipora verrucosa (Lamouroux 1821) (Fig. 28) is distributed in the Mediterranean and Atlantic. Colonies are erect and highly branched. In this survey, it was reported from two localities in the North (3, 5) and one locality in the Central Adriatic (18). All colonies were found between 10-40 m depth. In the vicinity of Rovinj, *F. verrucosa* was abundant on the soft bottom, on shell debris. In Sv. Juraj, it was also found on dead shell, while on Palagruža Island, *F. verrucosa* was found as epiphyte on the algae *Flabellia petiolata*.

4 Discussion

The Adriatic Sea is the northernmost part of the Mediterranean and it is characterized by the input of large amount of freshwater, with total annual average reaching about 5700 m^3/s (GAČIĆ et al. 2001). In a biogeographical sense, Adriatic Sea forms part of the Mediterranean entity. The benthic fauna of the Adriatic corresponds in its major part to that of the Mediterranean but also possesses some endemic species of its own. It is an interesting fact that certain species have been found exclusively in the northern Adriatic and the northern Atlantic. The benthic biocoenoses of the Adriatic also correspond in general to those of the Mediterranean; some, however, are distinguished by their special properties (GAMULIN-BRIDA 1967). This can probably be applied to the bryozoan fauna as well.

Bryozoans are not distributed haphazardly, but often occur in association with particular substrata. The greatest diversity of bryozoans and their maximum abundance lie between 20-80 m, with a peak of 40 m (RYLAND 1970). Their distribution also depends on food, temperature, salinity, seawater circulation, bathymetry etc. Because of this, it is not easy to explain the distribution of bryozoans. Thus, *Beania magellanica* was very abundant species along the escarpments of the North Adriatic, but it was not found at all along the escarpments in the South Adriatic (NOVOSEL et al. 2004). Furthermore, *Margaretta cereoides* was much more common in the South and Central Adriatic, since there is only one record of this species from the North Adriatic (HAYWARD & MCKINNEY 2002). Among surveyed biocoenoses, coralligenous biocoenosis harboured the larges diversity of bryozoans, followed by semi-cave biocoenosis, biocoenosis of seagrass *Posidonia oceanica* meadow and biocoenosis of photophilic algae. Since about 400 species have been recorded in the Mediterranean, future researches are expected to confirm much larger bryozoan diversity in the eastern Adriatic Sea.

Acknowledgment: I wish to thank A. Novosel for his invaluable help during the diving work and with the illustrations. I am greatly obliged to Dr. A. Požar-Domac and Dr. J.-G. Harmelin for their critical comments and useful suggestions on the manuscript. The support of the Ministry of Science, Education and Sport of the Republic of Croatia (Projects No. 119125 and Croatian National Monitoring Programme: Systematic Research of the Adriatic Sea as a Base for Sustainable Development of the Republic of Croatia) is acknowledged.

5 References

COCITO S., NOVOSEL M. & A. NOVOSEL (2004): Carbonate bioformations around underwater freshwater springs in the north-eastern Adriatic Sea. — Facies **50**: 13-17.

DONATI V. (1750): Della storia naturale marina dell'-Adriatico. — Francesco Storti, Venezia: 55-58.

FRIEDL P.H. (1918): Bryozoen der Adria. — Zool. Anz. **49**: 225-240, 268-280.

GAČIĆ M., POULAIN P.-M., ZORE-ARMANDA M. & V. BARALE (2001): Overview. — In: CUSHMAN-ROISIN B., GAČIĆ M., POULAIN P.-M. & A. ARTEGIANI (Eds.): Physical Oceanography of the Adriatic Sea. Kluwer Academic Publishers, The Netherlands: 1-9.

GAMULIN-BRIDA H. (1967): The benthic fauna of the Adriatic Sea. — Oceanogr. Mar. Biol. Ann. Rev. **5**: 535-568.

HARMELIN J.G. (1970): Les *Cribrilaria* (Bryozoaires Chilostomes) de Méditerranée: systématique et écologie. — Cah. Biol. Mar. **11** (1): 77-98.

HARMELIN J.G. (1973a): Morphological variations and ecology of the recent cyclostome bryozoan *Idmonea atlantica* from the Mediterranean. — In: LARWOOD G.P. (Ed.): Living and Fossil Bryozoa. Academic Press, London: 95-106.

HARMELIN J.G. (1973b): Bryozoaires de l'herbier de Posidonies de l'île de Port-Cros. — Rapp. Comm. int. Mer. Médit. **21** (9): 675-677.

HARMELIN J.G. (1976): Le sous-ordre des Tubuliporina (Bryozoaires Cyclostomes) en Méditerranée, écologie et systématique. — Mém. Inst. Océan. Monaco **10**: 1-326.

HARMELIN J.G. (1990): Interactions between small sciaphilous scleractinians and epizoans in the Northern Mediterranean, with particular reference to bryozoans. — Mar. Ecol. **11**(4): 351-364.

HARMELIN J.G. (2000): Ecology of cave and cavity dwelling bryozoans. — HERRERA CUBILLA A. & J.B.C. JACKSON (Eds.): Proc. 11th Intern. Bryozool. Assoc. Conf. Smithsonian Tropical Research Institute, Panama: 38-53.

HARMELIN J.G., BOURY-ESNAULT, N. & J. VACELET (1994): A bryozoan-sponge symbiosis: the association between *Smittina cervicornis* and *Halisarca* cf. *dujardini* in the Mediterranean. — In: HAYWARD P.J., RYLAND J.S. & P.D. TAYLOR (Eds.): Biology and Palaeobiology of Bryozoans. IBA, Swansea: 69-74.

HAYWARD P.J. & F.K. MCKINNEY (2002): Northern Adriatic Bryozoa from the vicinity of Rovinj, Croatia. — Bull. Am. Mus. Nat. Hist. **270**: 1-139.

HAYWARD P.J. & J.S. RYLAND (1999): Cheilostomatous Bryozoa Part 2. Aeteoidea – Cribrilinoidea. — Synopses of the British Fauna (New Series), Acad. Press. London **14**: 1-416.

HELLER C. (1867): Die Bryozoen des Adriatischen Meeres. — Verh. Zool. Bot. Ges. **17**: 77-136.

HINCKS T. (1886): The Polyzoa of the Adriatic: a supplement to Prof. Heller's "Die Bryozoen des Adriatischen Meeres". — Ann. Mag. Nat. Hist. **17**: 254-271.

HONDT J.-L. D' (2002): The French pre-Lamarckian bryozoologists. — In: WYSE JACKSON P.N. & M.E. SPENCER JONES (Eds.): Annals of Bryozoology: Aspects of the History of Research on Bryozoans. IBA, Dublin: 81-95.

JURAČIĆ M., NOVOSEL A., TIBLJAŠ D. & D. BALEN (2004): Jabuka Shoal, a new location with igneous rocks in the Adriatic Sea. — Geol. Croat. **57** (1): 81-85.

MCKINNEY F.K. & A. JAKLIN (2000): Spatial niche partitioning in the *Cellaria* meadow epibiont association, northern Adriatic Sea. — Cah. Biol. Mar. **41**: 1-17.

MCKINNEY F.K. & A. JAKLIN (2001): Sediment accumulation in a shallow-water meadow carpeted by a small erect bryozoan. — Sediment. Geol. **145**: 397-410.

NOVOSEL M. & A. POŽAR-DOMAC (2001): Checklist of Bryozoa of the eastern Adriatic Sea. — Nat. Croat. **10** (4): 367-421.

NOVOSEL M., POŽAR-DOMAC A. & M. PASARIĆ (2004): Diversity and distribution of the Bryozoa along underwater cliffs in the Adriatic Sea with special reference to thermal regime. — Mar. Ecol. **25** (2): 155-170.

NOVOSEL M., OLUJIĆ G., COCITO S. & A. POŽAR-DOMAC (2005): Submarine freshwater springs: a unique habitat for the bryozoan *Pentapora fascialis*. — Proc. 13th IBA, Chile (in press).

PÉRÈS J.M. & J. PICARD 1964: Nouveau manuel de bionomie benthique de la Mer Méditerranée. — Rec. Trav. Stat. mar. Endoume **31** (47): 3-137.

POŽAR-DOMAC, A., KRUŽIĆ, P., NOVOSEL, M. & I. RADIĆ, 2004: Threats to seagrass *Posidonia oceanica* meadows in the Adriatic Sea. — Proc. Littoral 2004, Aberdeen, Scotland **2**: 739-740.

RIEDL R. (1966): Biologie der Meereshöhlen. — Paul Parey, Hamburg: 1-636.

ROMERO COLMENERO L. & J.L. SÁNCHEZ LIZASO (1999): Effects of *Calpensia nobilis* (ESPER 1796) (Bryozoa: Cheilostomatida) on the seagrass *Posidonia oceanica* (L.) DELILE. — Aquat. Bot. **62**: 217-223.

RYLAND J.S. (1970): Bryozoans. — Hutchinson University Library, London: 1-175.

ZAVODNIK D., JAKLIN A., RADOŠEVIĆ M. & N. ZAVODNIK, 2000: Distribution of benthos at Jabuka, an islet of volcanic rock (Adriatic Sea). — Period. biol. **102**(2): 157-167.

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